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STRATEGIES FOR GROWTH IN A MACROECONOMIC SETTING*

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I INTRODUCTION

The theory of economic growth is meant to explain long-run developments. As is well known, the neoclassical version of the theory is not fully satisfactory as it attributes long-term growth to exogenous factors like technological change and population growth. In the past, new theories were developed to overcome this deficiency of the standard growth theory. In endogenous growth theories, the long-run growth rate of the economy depends upon preferences for consumption over time and parameters which relate to some "engine of growth". Although theories differ a great deal with respect to the specification of the "engine of growth", the savings rate holds a central position in all of them. Population growth is taken into account in some theories but not in others. Moreover, population growth may induce accelerating growth rates in theories where the "engine of growth" depends, among other things, on labour as the non-reproducible factor of production.

From an intellectual point of view the new growth theory may be considered as an improvement *vis-à-vis* its predecessor as it explains more. However, a final assessment should be based on empirical tests of both theories. For the time being there seems to be no clear indication which theory is to be preferred. The problem with the empirical implementation of both theories is that in the neoclassical theory savings matter also during the process of transition towards a steady state. And such transition processes may take substantial time.

Growth theories are set up to explore trends but there may be shifts in long-run development that mark different episodes in stories about growth. The development of rich economies from 1950 to roughly 1970 seems to be different from the more recent pattern of economic growth. The productivity slow-down envisaged after 1970 is not well explained by neoclassical growth theory but the same verdict holds for the new growth theory also (Scott, 1989). Consequently, there is need for extensions of the theory. Endogenous growth theory may be a promising start but is not fully satisfactory as the theory ignores institutional and organizational factors, which may prove

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important explanatory points (e.g., Stern, 1991). The relevance of these factors for understanding economic growth is most clearly revealed in publications based on careful analysis of case studies. For instance, in Detouzos *et al.* (1989) the problem is stated in the following terms:

> If organizational and attitudinal deficiencies do indeed have an important bearing on American industrial performance as our findings indicate, then a purely macroeconomic approach is insufficient. This is because there is no efficient market in which organizational forms and attitudinal complexes compete with one another. (pp. 38–39).

However, macroeconomic analysis is well suited to deal with market imperfections and a number of issues discussed in the quoted study may fall under this heading. The authors emphasize factors such as the application of outdated strategies, short time horizons and technological weaknesses in development and production in the U.S. economy. In order to get a clear picture of what is meant by these factors, a descriptive approach is essential. Outdated strategies relate to a focus on mass production, which is superseded by developments in the market. A reorientation of strategy is not easy because individual parts of the traditional pattern cannot be replaced piecemeal. Short time horizons are closely connected to the organizational structure of capital markets and the way in which executives' motives are linked to the financial result of the firm. Technological weaknesses may emerge if lower-risk investments dominate alternatives based on the integration of product and process engineering, for example. Similar observations on corporate strategies and managerial attitudes in the U.S. economy over recent years are made in Porter (1990, Ch. 9).

Although theory inevitably implies abstraction, endogenous growth theory can be improved by taking account of some of the factors just mentioned. The aim of the present paper is to make a start in that respect by extending in several directions a theory of endogenous growth along the lines set by Scott (1989, 1991). Scott's theory based on learning-by-doing is discussed in Section II. Accordingly, the traditional static production function is replaced by a fundamental growth equation, which makes the model very flexible and powerful. Section III describes a competitive market equilibrium. Learning externalities, which are the topic of Section IV, fit easily into the framework. Coordination of investment in the presence of the learning externalities proves to be a feasible alternative for a market economy. In Section V it is assumed that managers have some discretion with respect to the goals set for the firm. Growth maximization subject to constraints is considered as an alternative for maximization of the value of the firm. At this point the analysis bears some resemblance to the theory of managerial economics (Marris, 1964, 1971), which did not receive the attention it deserved. This may be due to the fact that it is set up as a theory of the firm rather than as a theory of economic growth. Uncertainty and growth is the subject of Section VI. Investment programmes have to cope with uncertainty. A theory of growth can therefore not ignore the uncertainty connected with the returns on investment. However, from an analytical point of view it is difficult to incorporate this aspect in a satisfactory manner but that may be no excuse to eliminate uncertainty, as is standard practice in growth theory. Section VII contains some conclusions and suggestions for further research.

II A THEORY OF ENDOGENOUS GROWTH

The new theory of economic growth of Scott (1989, 1991) is based on a simple but powerful view of the world. Ongoing production processes are seen as a heritage from the past. Increases in production can be brought about by changing production processes and by changing existing economic arrangements, which require investment outlays to be made. At the same time, every transformation implies problem solving from which people learn. Therefore, as in Arrow (1962), investment leads to learning-by-doing and the level of knowledge depends on accumulated gross investment. Investment problems build upon their predecessors. But this also implies that investments have an "option value", which is defined in Myers (1984) as the present value of future opportunities that will be opened up if the investment is made. Diminishing returns to capital accumulation may be absent as investment opportunities are recreated by undertaking investment and over time their average quality does not change very much for the whole economy.

Investment leads to growth in output and change in employment. However, there may be different options with respect to the labour-saving character of investment programmes. Cost consideration may induce firms to opt for investment programmes with more or less growth or a decline of employment. Moreover, there are diminishing returns with respect to the rate of investment. At any moment in time, firms have to choose from a set of investment projects which are not equally profitable. The most profitable projects are chosen first. Consequently, the larger the rate of investment, the lower is the average quality of the selected projects. However, the average quality of the entire set of available investment opportunities does not diminish over time because of learning-by-doing.

To capture these ideas Scott introduces what we will call a fundamental growth equation which describes the set of investment possibilities generated by past investment. Fig. 1 illustrates how the possibilities can be characterized in terms of labour-saving bias and the size of investment. The symbols g, g_l and σ denote the growth rate of (potential) output, the growth rate of labour input (employment) and the gross investment ratio, respectively.

For a given rate of investment (say $\sigma_1 > 0$), there is a trade-off between slow but labour-saving growth (e.g., point A) and fast but labour-using growth (e.g., point B). The curve $\sigma_1\sigma_1$, representing the efficient combinations of g and g_l that can be attained, resembles the Innovation Possibilities Frontier

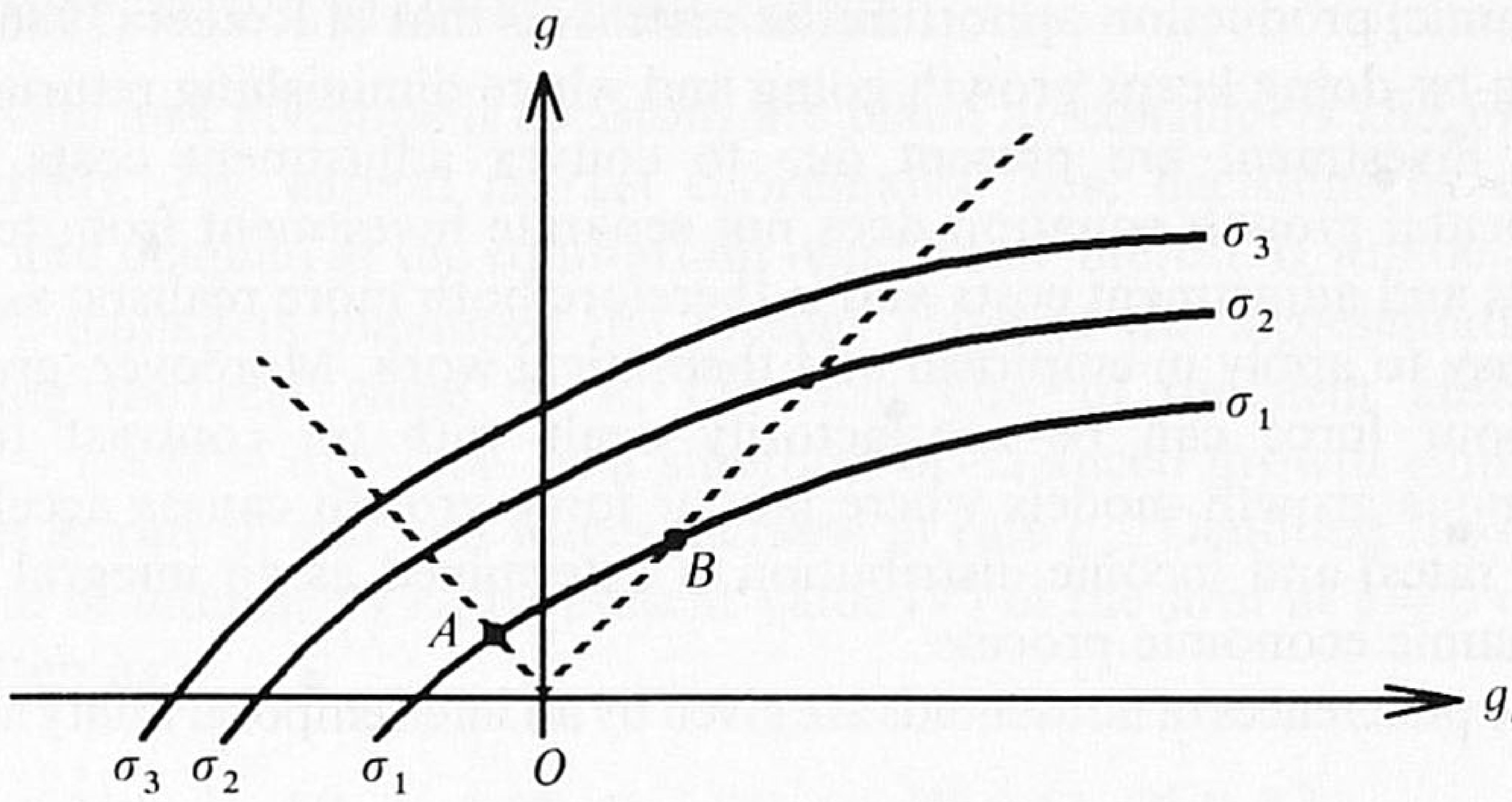


FIG. 1 The Investment Possibilities Set

introduced by Kennedy (1964) and Von Weizsäcker (Samuelson, 1965). However, the position of the frontier depends here on the rate of investment (σ): greater investment expenditure permits both growth and labour saving to rise (e.g., along ray OA), which shifts the frontier up from $\sigma_1\sigma_1$ to $\sigma_2\sigma_2$. As argued above, there are diminishing returns with respect to (point in time) investment so further increases of investment (e.g., from σ_2 to σ_3) shift the curve by less.[1]

If each curve is stable over time, growth can be sustained for a constant rate of investment and employment growth. The recreation of new investment opportunities through learning-by-doing prevents the returns to investment falling over time, so that the curves $\sigma\sigma$ are stable. This assumption allows for endogenous growth. If the creation of new knowledge were absent or insufficient, diminishing returns would cause each curve $\sigma\sigma$ to shift towards the origin over time and growth would peter out eventually.

The mathematical formulation of the investment possibilities set is given by the fundamental growth equation:[2]

$$g = g(g_l, \sigma) \qquad \begin{array}{lll} \partial g/\partial\sigma > 0 & \partial^2 g/\partial\sigma^2 < 0 & \partial^2 g/\partial g_l \partial\sigma > 0 \\ \partial g/\partial g_l > 0 & \partial^2 g/\partial g_l^2 < 0 & g(g_l, 0) = 0 \end{array} \tag{1}$$

Equation (1) may be called a primitive (as in Romer, 1991), but the same verdict applies to the neoclassical production function for which there is no strict need in a theory of economic growth. To some extent, this modelling

[1]The curve for $\sigma = 0$ coincides with point O in Fig. 1 as no growth is possible without investment. Output and investment are measured net of necessary expenditures on maintenance because of wear and tear, so zero investment does not cause potential output to fall.

[2]Our formulation differs somewhat from Scott's original formula, which is cast in terms of the "dynamic input coefficients" g/σ and g_l/σ. To allow for diminishing returns in σ, Scott has to add an additional factor in σ which makes his specification somewhat cumbersome (see our Appendix).

of (dynamic) production opportunities resembles that of Romer (1986) where learning-by-doing keeps growth going and where diminishing returns to the rate of investment are present due to convex adjustment costs. Scott's fundamental growth equation does not separate investment from technical progress and adjustment costs and is therefore both more realistic as well as more easy to apply in empirical and theoretical work. Moreover, growth in the labour force can be satisfactorily dealt with (in contrast to most endogenous growth models where labour force growth causes accelerating growth rates) and income distribution is determined as an integral part of the dynamic economic process.

The preferences of households are given by an intertemporal utility function:

$$U = \int_0^\infty u(c_i)e^{-\theta t}\,dt$$

where c_i denotes per capita consumption and θ denotes the pure rate of time preference. It is convenient to assume a constant coefficient of relative risk aversion, ρ, so that the instantaneous CRRA utility function can be written as:

$$u(c_i) = \frac{c_i^{1-\rho}}{1-\rho}$$

Goods market equilibrium implies that (aggregate) output (y) equals aggregate consumption (c) and investment expenditure (i):

$$c = y - i = (1-\sigma)y \tag{2}$$

where $\sigma \equiv i/y$ denotes the (macroeconomic) investment ratio which is an endogenous variable of the model. To concentrate on issues of strategic interaction only paths of balanced growth are taken into consideration. The more general case where growth rates change over time is analysed in van de Klundert and Meijdam (1993). It is shown there that the model has no transition dynamics in its standard setting, as holds for other endogenous growth models with a broad concept of capital accumulation (e.g., Sala-i-Martin, 1990). It is, therefore, legitimate to restrict our analysis here to steady-state solutions. Traditional dynamics come into play when there is some inertia in markets (e.g., sluggish wage or price adjustment), when firms with low labour productivity can grow faster because of catch-up possibilities, or when structural shocks are anticipated. However, several interesting conclusions can be drawn from the setting without transitional dynamics.

Denoting the growth rate of output by g and that of per capita consumption by g_c we have:

$$y = y(0)e^{gt} \tag{3}$$

$$c_i = c_i(0)e^{g_c t} \tag{4}$$

Assuming that the population grows at the exogenous rate g_n we may write $g = g_c + g_n$.

III Competitive Market Equilibrium

The saving and investment decisions are taken by consumers and producers respectively. The capital market coordinates these decisions by equating supply and demand at the equilibrium real rate of interest. It will be assumed that the managers maximize the present value of the representative firm. Denoting the real wage by w, the cash flow of the firm amounts to $y - lw - i = (1 - \sigma)y - lw$. In a situation of balanced growth employment changes at rate g_l and real wages increase at rate g_w. Denoting the constant real rate of interest by r, the present value (V) of the firm at $t = 0$ can then be written as:

$$V = \int_0^\infty [(1 - \sigma)y(0)e^{gt} - l(0)e^{g_l t} w(0)e^{g_w t}]e^{-rt}dt \tag{5}$$

Firms have to form expectations as to the growth of wages and future interest rates determined on the factor markets. Here we assume rational expectations which implies that expected values for wage growth and interest rate equal the actual values. Solving the integral above for a constant σ, provided that $r > g$, yields:

$$V = y(0)\left(\frac{1 - \sigma}{r - g} - \frac{\lambda}{r - (g_l + g_w)}\right) \tag{6}$$

where $\lambda \equiv l(0)w(0)/y(0)$ denotes the share of output accruing to labour in the initial situation. It should be noticed that the steady-state value of λ is an endogenous variable. As there is no transition dynamics, the steady-state value of λ is determined by the labour market-clearing real wage rate, w. Firms maximize V with respect to the investment ratio (σ) and the rate of change of employment (g_l). Maximization of V is constrained by the growth equation (1) so we can replace g by $g(g_l,\sigma)$. Moreover, initial output has to be taken as given because levels cannot be changed without investing. To simplify, $y(0)$ is set at unity.

The first-order conditions are:

$$\frac{\partial V}{\partial \sigma} = -\frac{1}{r - g} + \frac{1 - \sigma}{(r - g)^2}\frac{\partial g}{\partial \sigma} = 0$$

$$\frac{\partial V}{\partial g_l} = \frac{1 - \sigma}{(r - g)^2}\frac{\partial g}{\partial g_l} - \frac{\lambda}{[r - (g_l + g_w)]^2} = 0$$

Assuming that the economy exhibits balanced growth with $g - g_l = g_w$, so that λ is constant, results in:

$$(1 - \sigma)\cdot \partial g/\partial \sigma = r - g \tag{7}$$

$$(1 - \sigma)\cdot \partial g/\partial g_l = \lambda \tag{8}$$

The optimum conditions (7) and (8) are easily interpretable. According to equation (7), the proportionate marginal product of investment corrected for growth costs (measured by σ) should be equal to the growth-corrected real rate of interest. Equation (8) implies that the proportionate marginal product of labour again corrected for growth costs should be equal to the share of labour in output. Equation (7) determines the optimal amount of investment, whereas the labour saving bias follows from equation (8).

To specify consumers' behaviour, it will be assumed that the representative and infinitely lived household maximizes the intertemporal utility function given above subject to an intertemporal budget constraint by choosing the level of per capita consumption. The dynamic budget constraint can be written as:

$$\dot{a}_i = w + (r - g_n)a_i - c_i$$

where a_i denotes per capita non-human wealth. The non-consumed parts of interest and labour income add to the stock of family wealth. A rise in the size of the household has a negative effect on individual wealth because total household wealth must be shared by more persons. The first-order condition for the optimal consumption plan boils down to the well-known Keynes-Ramsey rule:

$$g_c = \dot{c}_i/c_i = (r - \theta - g_n)/\rho$$

Aggregation over individual consumers, whose number increases at rate g_n, gives the growth rate of aggregate consumption $\dot{c}/c = g_c + g_n$. Equilibrium in the capital market assures equality of aggregate non-human wealth and aggregate firm value. Equilibrium in the output market relates aggregate consumption to output according to $c = (1 - \sigma)y$ (equation (2) above). In a situation of balanced growth the savings/investment ratio σ and the growth rate of output $\dot{y}/y = g$ are constant so that $\dot{c}/c = g$ and the Ramsey rule can be rewritten as:

$$r = \theta + g_n + \rho(g - g_n) \tag{9}$$

Concerning the labour market, labour supply is exogenous and increases at rate g_n, assuming a constant participation rate of the population. Labour market equilibrium requires:

$$g_l = g_n \tag{10}$$

If wages are fully flexible, this equilibrium condition applies at each moment in time. As discussed in van de Klundert and Meijdam (1993), this condition obtains as a steady-state result in case of labour market clearing (zero unemployment) as well as in the case with some form of equilibrium unemployment in the labour market. It should be noticed that market equilibrium is defined in terms of flows and not necessarily in terms of stocks. All that is needed is that the increase in output is sold and that the change in labour supply is absorbed in the production process to the extent that the capacity utilization ratio and the unemployment rate remain constant.

From this point of view, it is obvious that the model may exhibit hysteresis in levels as do many other endogenous growth models.

The complete market model comprises equations (1), (7)–(10), solving for the endogenous variables g, g_l, σ, λ and r. Substitution of (1) and (10) into (7)–(9) yields:

$$r - g = [\theta - (\rho - 1)g_n] + (\rho - 1)g(g_n,\sigma) \tag{11}$$

$$r - g = (1 - \sigma)\cdot\partial g(g_n,\sigma)/\partial\sigma \tag{12}$$

$$\lambda = (1 - \sigma)\cdot\partial g(g_n,\sigma)/\partial g_l \tag{13}$$

The solution of the model is presented in Fig. 2. Equations (11) and (12) are shown by the curves labelled *SS* and *II* respectively in the central panel. The curves indicate which rate of saving is optimally chosen by consumers[3] and which rate of investment is optimally chosen by firms, both as a function of $r - g$. The intersection of the curves gives the savings investment equilibrium and determines σ (along with $r - g$). The equilibrium growth rate g is determined by equation (1) with $g_l = g_n$, as depicted in the upper panel. Equation (13) is depicted by the curve labelled *DD* in the lower panel to determine the share of labour income λ. Note that the slope of this curve is:

$$\frac{d\lambda}{d\sigma} = \frac{\partial g/\partial g_l}{\sigma}[\eta - (1 + \eta)\sigma]$$

where $\eta \equiv \sigma \quad \dfrac{\partial^2 g}{\partial\sigma\,\partial g_l}\bigg/\dfrac{\partial g}{\partial g_l} > 0$

Hence as the *DD* curve slopes downward over a larger range, the less sensitive is the proportionate marginal product of labour ($\partial g/\partial g_l$) with respect to the investment ratio (i.e., the smaller the elasticity η). This implies that the curves $\sigma\sigma$ in Fig. 1 are relatively flat. Empirical work in Scott (1989) supports this case and we can assume that, for realistic values of σ, we have $d\lambda/d\sigma < 0$.

A rise in the growth rate of labour supply (g_n) is illustrated by the broken lines. The new equilibrium is at points L, L' and L'': growth rises and the share of output accruing to labour falls. A rise in the pure rate of time preference shifts the *SS* line up, as illustrated by the dotted line. The new equilibrium is at points T, T' and T'': the growth rate and the investment ratio decline unambiguously and the share of labour in output rises.

A numerical illustration of the latter case is given in Table 1 (second column). If consumers have less patience the rate of savings declines, which leads to lower investment and growth. The share of labour rises, because growth costs fall, so that the net proportionate marginal product of labour increases on balance despite a shift towards less labour-saving projects.

[3]In Fig. 2, it is assumed that $\rho > 1$ which is the empirically relevant case. If $0 < \rho < 1$, the *SS* curve slopes downward, but the same comparative static results apply for changes in g_n and θ.

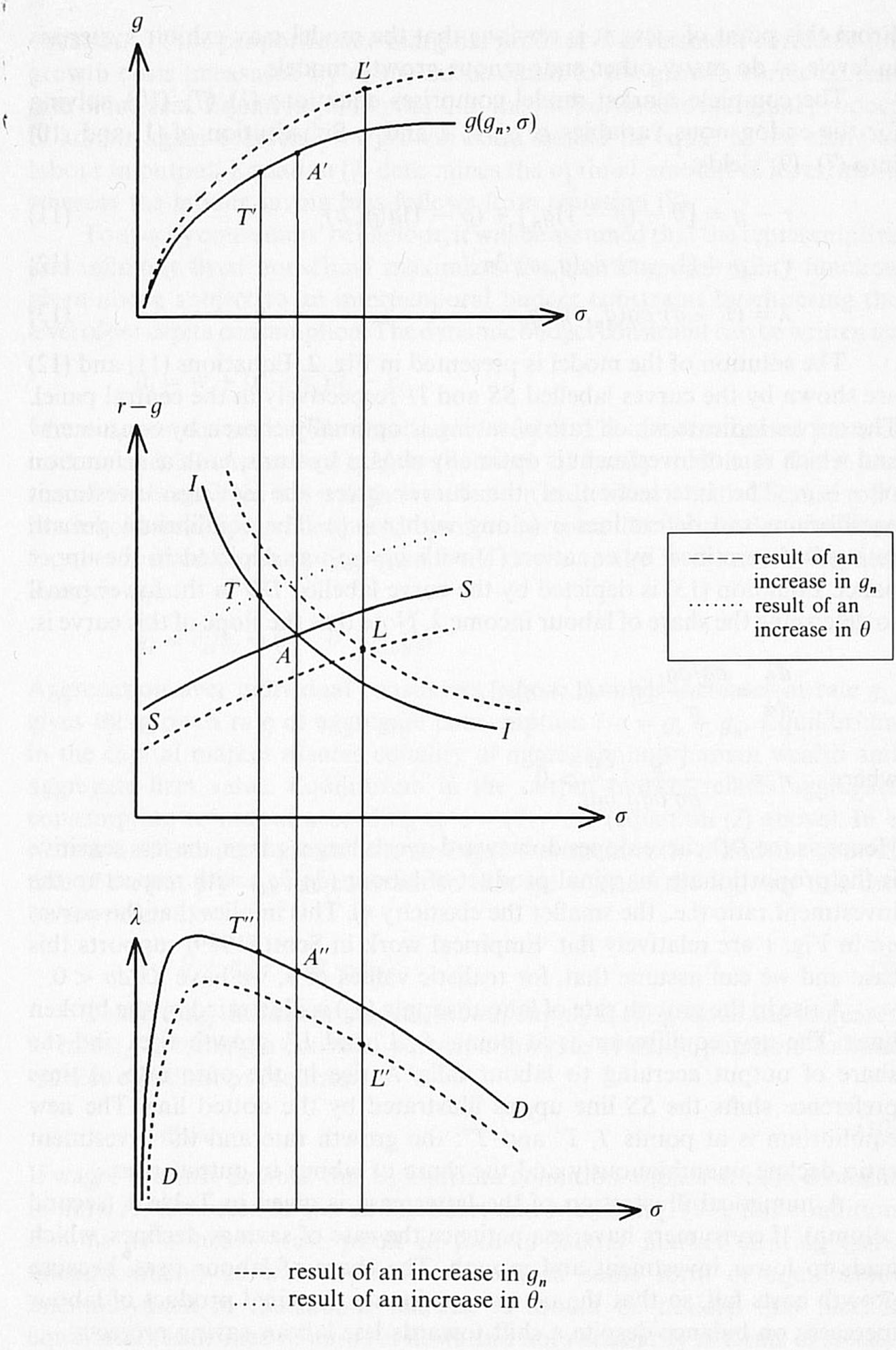


FIG. 2 The Determination of the Equilibrium

TABLE 1[a]

	Benchmark	*Increased Time Preference*	*Learning-By-Watching*	*Coordinating Investment*
g	3·40%	3·14%	3·89%	4·18%
σ	0·1913	0·1567	0·1968	0·2275
λ	0·7439	0·7721	0·7435	0·7170
r	9·02%	10·35%	10·24%	10·96%

Note: [a] See Appendix for model specification and parameter choices.

Higher cost of capital pushes U.S. firms in the direction of a shorter time horizon as Detouzos *et al.* (1989) argue in comparing the performance of the U.S. economy with that of its competitors. But there may be additional factors which exert a downward pressure on growth rates in general. In the sections below the model will be extended to allow for further perspectives in explaining economic growth.

IV The Coordination Perspective

New investment opportunities not only arise from the firm's own investment: to a large extent a firm's investment opportunities are created by learning from investments undertaken by other firms. *Learning-by-doing* has to be supplemented with *learning-by-watching* (e.g., King and Robson, 1993). There is clearly an externality involved.

The individual investor captures only a fraction of the social benefits from its own investment as benefits accrue in part to other firms. Consequently, firms have a low private incentive to invest. However, if entrepreneurs realize that they are in the same position, they may try to coordinate investment in order to capture fully the benefits of each other's investment. As documented by Weder and Grubel (1993), learning externalities will induce the creation of private institutions capable of internalizing them, e.g., industry associations and other inter-industry relations. If firms succeed in establishing these institutions and in convincing each other to coordinate certain aspects of investment, profits for all firms are higher than without coordination. To overcome coordination failures and free-rider problems, a certain cultural attitude towards coordination may be necessary.

Learning-by-watching can be built into the model by assuming that investment by other firms raises the marginal return of investment for the individual company. Denoting the individual firm's investment ratio by σ and the average investment ratio for the economy by σ_s, the fundamental growth equation may now be written as:

$$g = g(g_l, \sigma, \sigma_s) \quad (14)$$

In addition to the conditions imposed on (1), we require $\partial g/\partial\sigma_s > 0$ and $\partial^2 g/\partial\sigma\partial\sigma_s > 0$.

After substitution of (14) into (6), the first-order conditions for value maximization, which can be derived as above, yield:

$$r - g = (1 - \sigma)[\partial g/\partial\sigma + \alpha\cdot\partial g/\partial\sigma_s]$$
$$\lambda = (1 - \sigma)\cdot\partial g/\partial g_l \qquad (15)$$

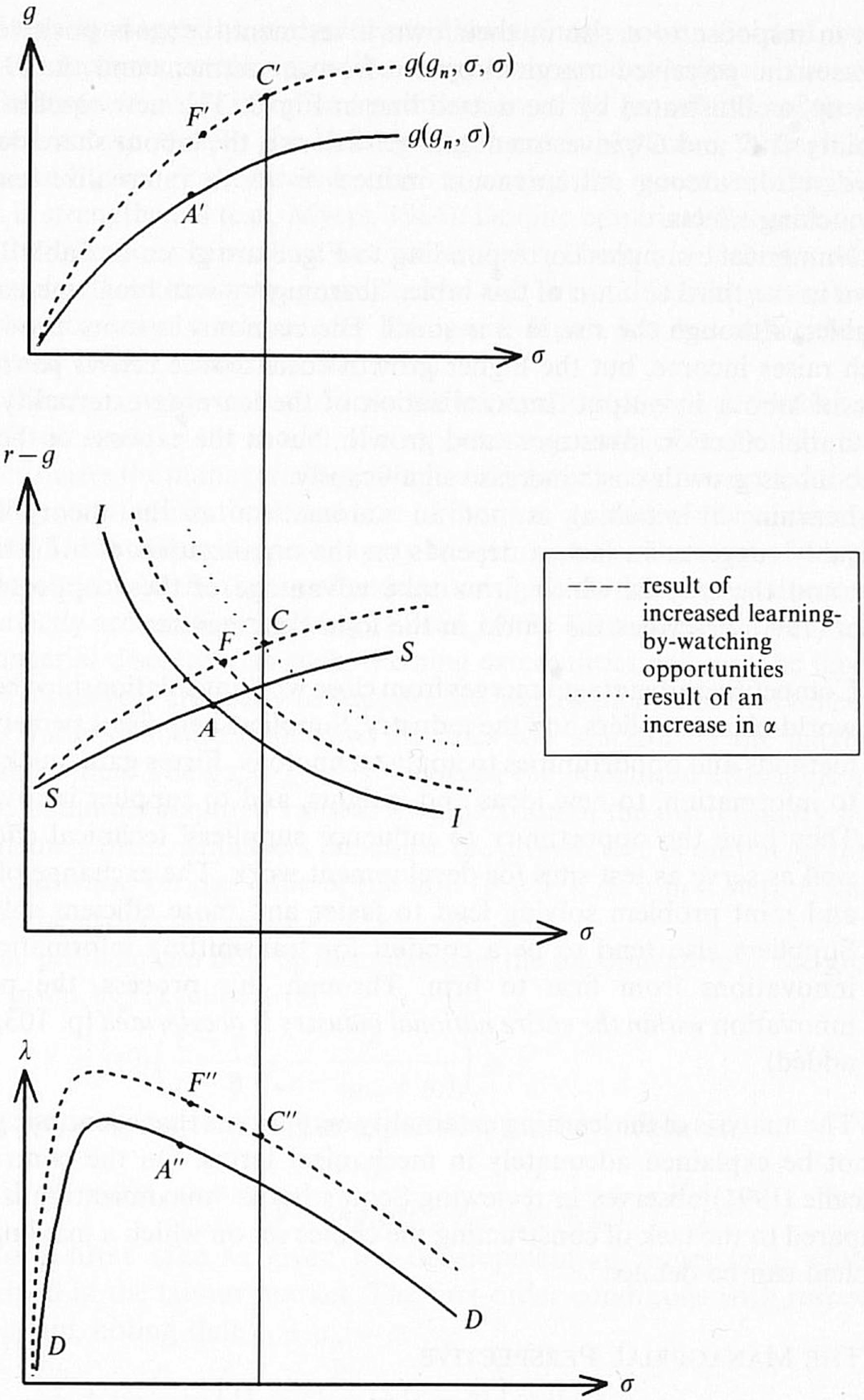
where we assume that it is anticipated that other firms will change their investment ratio by α per cent in response to a 1 per cent own change in the investment ratio (conjectural variation). Entrepreneurs are aware of the direct returns to own investment ($\partial g/\partial\sigma$) and they know how much they can benefit from other firms' investment ($\partial g/\partial\sigma_s$) but they are uncertain about the reaction of other firms to changes in own investment. Severe coordination failures imply a small value of α. The perceived indirect marginal benefits of own investment depend on the perceived reaction α and on the actual rate of investment in the economy σ_s. In other words, equation (15) is the firm's reaction curve.

In a symmetric equilibrium, the average economy-wide investment ratio σ_s is equal to the rate of investment of each firm ($\sigma = \sigma_s$).[4] Furthermore, equations (9) and (10) apply and the solution can be presented in a similar way as above, see Fig. 3.

Consider first the impact of opportunities for learning-by-watching in an economy without coordination ($\alpha = 0$). We can think of two economies, one faced with the learning opportunities as in the previous section, the other with learning-by-watching opportunities in addition. The latter economy has developed over its history a structure of industry that permits more learning than the former because of communication networks, infrastructure, technological integration, etc.. Firms in both countries apply the same decision rules with respect to investment (with $\alpha = 0$ equation (15) coincides with (7)). However, aggregate learning opportunities in the second economy are larger, as illustrated by the broken line in the upper panel of Fig. 3. At a given rate of investment, the second economy grows faster. Firms have a larger incentive to invest because $\partial g/\partial\sigma$ is higher, which causes the *II* curve for the economy to be higher (central panel). However, larger growth means a higher cost of capital (the *SS* curve is higher and equilibrium is at point *F*), and the rate of investment is not necessarily higher than in the pure learning-by-doing economy.

Next, consider the impact of coordination in an economy with learning-by-watching opportunities. All firms anticipate a stronger reaction by other

[4]Learning externalities can be incorporated in a macroeconomic framework only in a very stylized way. Learning from other firms is only possible if firms have *different* knowledge, i.e., if firms differ in a *qualitative* sense. However, to obtain tractable aggregation results in a macroeconomic setting it is required also that firms are of equal size, i.e., that firms are the same in a *quantitative* sense.



---- result of increased learning-by-watching opportunities

..... result of an increase in α.

FIG. 3 Learning-By-Watching and Coordination firms in response to a rise in their own investment, i.e., α is positive. This increases the perceived marginal benefit from investment and the II curve shifts up, as illustrated by the dotted line in Fig. 3. The new equilibrium is at points C, C' and C''; investment and growth rise, the labour share declines. Coordination among entrepreneurs induces firms to internalize learning-by-watching effects.

Numerical examples corresponding to Fig. 3 are given in Table 1. As is shown in the third column of this table, "learning-by-watching" increases all variables, although the rise in λ is small. The economy is more productive, which raises income, but the higher growth costs reduce *ceteris paribus* the share of labour in output. Internalization of the learning externality has a substantial effect on investment and growth, but at the expense of the share of labour as growth costs increase significantly.

Learning-by-watching is not an automatism as the theory almost inevitably suggests. In fact, it depends on the organization of industry and trade and the way in which firms take advantage of these opportunities. Porter (1990) describes the world in the following manner:

> Competitive advantage emerges from close working relationships between world-class suppliers and the industry. Suppliers help firms perceive new methods and opportunities to apply technology. Firms gain quick access to information, to new ideas and insights, and to supplier innovations. They have the opportunity to influence suppliers' technical efforts as well as serve as test sites for development work. The exchange of R&D and joint problem solving lead to faster and more efficient solutions. Suppliers also tend to be a conduit for transmitting information and innovations from firm to firm. Through this process, the pace of innovation *within the entire national industry is accelerated* (p. 103, italics added).

The analysis of the learning externality emphasizes that economic growth cannot be explained adequately in mechanical terms. On the contrary, as Metcalfe (1991) observes in reviewing Scott's book: "maximization is trivial compared to the task of constructing the choice set on which a maximization problem can be defined".

V The Managerial Perspective

Managerial-controlled firms have discretionary power to pursue other goals than present-value maximization. As hypothesized by Marris (1964, 1971) such firms would seek to maximize growth of output subject to constraints set by the capital market. In Marris (1964, Ch. 2) managerial motivation is discussed extensively, taking account of psychological, sociological and economic motives. However, the view is not undisputed. First, it may be questioned whether there is a separation of ownership from control to the extent that managers have significant discretionary power. Second, even if there is such power, certain incentives may favour present-value maximization over alternatives, as for instance maximization of the growth rate of the firm. It is well known that in the U.S. management is rewarded through stock options and other profit-related schemes, so that the incentive to maximize profits is strengthened (e.g., Myers, 1984). Despite empirical research on this issue, the questions raised are not yet settled.[5] There is a feeling among a number of authors that managerial control and deviations from present-value maximization may be relevant for Europe or Japan, but less so for the U.S. (e.g., Scott, 1989; Detouzos *et al.*, 1989).

It therefore makes sense to discuss the implications of growth maximization in the framework of the model of endogenous growth of Section II. Solow (1971) criticizes the managerial approach and related growth-oriented theories for failing to establish the initial size of the firm as part of the optimization problem. This critique does not apply to our model as the level of output is path-dependent. In the theory of endogenous growth this is a not uncommon and perfectly acceptable result (e.g., Lucas, 1988). To concentrate on the issue of managerial discretion as such, learning externalities will now be ignored. Financial markets are ready to support the management of a firm unless the present value of future cash flows deviates too much from the maximum attainable value. The gap $V_{\max} - \bar{V}$ between the maximum attainable value and the minimum required value is an indication of the discretionary power of the management. Managers maximize the growth rate of output (g) subject to the constraint on the value of the firm ($V \geqslant \bar{V}$). As a first step, $\bar{V}$ can be taken to be exogenous (with $\bar{V} < V_{\max}$).[6]

The problem can now be formulated as the maximization of the growth rate g, given by (1), subject to:

$$V = y(0)\left(\frac{1-\sigma}{r-g} - \frac{\lambda}{r-(g_w+g_l)}\right) \geqslant \bar{V} \tag{16}$$

Setting $y(0) = 1$, the Lagrangian expression can be written as:

$$\mathscr{L} = g(g_l, \sigma) + \xi\left(\frac{1-\sigma}{r-g(g_l,\sigma)} - \frac{\lambda}{r-(g_w+g_l)} - \bar{V}\right)$$

As before, firms take as given the development of wages (g_w), which is determined in the labour market. The first-order conditions with respect to σ and g_l are, noting that $g_l + g_w = g$:

$$\frac{\partial g}{\partial \sigma} + \frac{\xi}{(r-g)^2}\left((1-\sigma)\frac{\partial g}{\partial \sigma} - (r-g)\right) = 0$$

$$\frac{\partial g}{\partial g_l} + \frac{\xi}{(r-g)^2}\left((1-\sigma)\frac{\partial g}{\partial g_l} - \lambda\right) = 0$$

[5] For a discussion of some empirical studies, see Scott (1989, Ch. 9).

[6] To endogenize $\bar{V}$, a utility function for managers with arguments V and g can be introduced (*cf.* Marris, 1964).

In addition, the complementary slackness condition reads $\xi(V - \bar{V}) = 0$. Elimination of the Lagrangian multiplier (ξ) and rearranging yields:

$$\frac{\partial g/\partial \sigma}{\partial g/\partial g_l} = \frac{r-g}{\lambda} \tag{17}$$

$$\xi = \frac{(r-g)^2\, \partial g/\partial g_l}{\lambda - (1-\sigma)\, \partial g/\partial g_l} \tag{18}$$

Equation (17) determines the optimal combination of investment and employment growth: the marginal rate of transformation (LHS) equals the price ratio (RHS). The constraint is binding (i.e., $V = \bar{V}$) if the multiplier (ξ) is positive. This is the case, as can be shown as follows. The value of a firm in a situation of balanced growth, with $y(0) = 1$, is given by (*cf.* equation (6)):

$$V = (1 - \sigma - \lambda)/(r - g)$$

Substituting the first-order condition for value maximization (8), we can express the maximum value as:

$$V_{\max} = \frac{(1-\sigma) - (1-\sigma)\, \partial g/\partial g_l}{r-g}$$

Since $V \leqslant V_{\max}$, we have $\lambda \geqslant (1-\sigma)\partial g/\partial g_l$ and, from (18), $\xi \geqslant 0$, which implies that the constraint is binding:

$$(1 - \sigma - \lambda)/(r - g) = \bar{V} \tag{19}$$

With regard to the labour market and the supply of financial funds, the same assumptions are made as in Sections II and III. The complete managerial model then comprises equations (1), (9), (10), (17) and (19), which solve for g, g_l, λ, σ and r. The solution can be illustrated by a figure which is similar to Figs. 2 and 3. The *SS* curve (11) is unchanged. The *II* curve is found by eliminating λ between (17) and (19), while the *DD* curve is derived by eliminating $r - g$ between the same equations:

$$r - g = \frac{(1-\sigma)\, \partial g/\partial \sigma}{\partial g/\partial g_l + \partial \bar{V}/\partial \sigma} \qquad II \text{ curve}$$

$$\lambda = \frac{(1-\sigma)\, \partial g/\partial g_l}{\partial g/\partial g_l + \bar{V}\, \partial g/\partial \sigma} \qquad DD \text{ curve}$$

A comparison of the managerial model with the model of value maximization is equivalent to a comparison of an economy with strong financial market imperfections (low $\bar{V}$) and an economy with a less imperfect financial market (high $\bar{V}$ or even $\bar{V} = V_{\max}$). The lower the financial market constraint, the further away the *II* curve is positioned from the origin and the higher will be growth. This is, of course, what we would expect: less stockholders' control permits managers to pursue more empire building.

Calibrating the model, a less obvious result comes to light. The size of the impact of a change in $\bar{V}$ depends on the size of $\partial g/\partial\sigma$ relative to that of $\partial g/\partial g_l$ in the denominator of the equations above. Equation (17) suggests that this size is small as $r - g$ is typically small relative to λ.

TABLE 2[a]

	Value Maximization	Managerial Economy	
		Uncoordinated	Coordinated
g	3·40%	3·43%	3·96%
σ	0·1913	0·1941	0·3008
λ	0·7439	0·7608	0·6476
r	9·02%	9·06%	10·41%
V	1·155	0·8	0·8

Note: [a] See Table 1.

Comparison of the results in columns 1 and 2 in Table 2 confirms that the managerial alternative to maximization of the value of the firm has a very small impact on the growth rate of output even if the constraint on the value of the firm is not very restrictive. The reason for this perhaps unexpected result is the macroeconomic constraint of labour market equilibrium. A higher rate of growth leads *ceteris paribus* to a rising demand for labour but the increase in labour supply is exogenous in the model. Increased tension in the labour market induces a rise in the share of income accruing to labour, so that firms are under pressure to change towards relatively more labour-saving investment projects. This contrasts with the outcomes of managerial theory, which is based on a microeconomic setting.

However, the managerial approach may be introduced into the macro model in a different way. It may be assumed that firms maximize the growth rate of output but pay labour less than implied by condition (17). In this model variant, firms attract labour to maximize the value of the firm so that there are ample financial means to invest and maximize growth. Previous models of growth maximization did not take into account the labour-saving aspects of technological change (e.g., Marris, 1971). Therefore the problem of how to deal with labour demand did not arise. It can be argued that it is in the common interest of all managers to attract labour at a low wage. Low wage cost implies that the value of the firm is high and that the financial constraint leaves much room to realize high rates of investment and growth. However, in the standard setting, managers compete for labour in the labour market which drives up the wage. Hence, coordination among firms in the labour market serves managers' interest. Growth maximization calls for some form of collective rent extraction *vis-à-vis* labour. But if managers organize their interests, they may face constraints in the labour market, which prevent wages from declining below a certain level.

Here, we assume that managers coordinate action in the labour market and depress the income share of wages (λ) to the proportionate marginal product of labour, as in equation (8). Under these circumstances the model comprises equations (1), (8), (9), (10) and (19) and solves for g, g_l, σ, λ and r. The numerical outcomes of this exercise are presented in column 3 of Table 2. As may be expected, the growth rate is now substantially higher than in the variant where managers compete to attract labour in order to maximize growth subject to the same financial constraint, as shown in the fifth line of the table.

VI Growth Under Uncertainty

Usually firms operate in an uncertain outside world. These uncertainties relate to numerous relevant aspects of business conditions and prospective changes in the economy as well as to their consequences for the firm. As emphasized by Lintner (1971), in such a typical dynamic and uncertain environment firms develop policies and strategies for growth. Firms tend to operate in terms of expectations or targets of average growth rates for the future together with some assessment of the intensity of fluctuations around long-run averages. Formulating a strategic posture in these terms is, of course, a composite summary of the assessment of the more detailed environmental and competitive factors and the prospective success of firms in coping with these factors. Nevertheless, it seems worthwhile to envisage the strategic posture of the firm in terms of both a time path of expected growth and also a measure of risk or random variability about the expected trend. The basic policy decisions of firms can then be regarded as choosing among alternative pairs of expected growth rates and levels of risk on the one hand and fixing the desired intensity of labour savings on the other hand. To simplify matters these two basic decisions will be treated as unrelated.

As shown by Kormendi and Meguire (1985) and Grier and Tullock (1989), there is a positive relation between growth rates and the variability of growth rates which can be considered as a measure of risk. Expected growth can be increased at a given rate of investment and employment growth only at the cost of a higher risk. The fundamental growth equation may therefore be written as:

$$\bar{g} = \bar{g}(g_l, \sigma, var) \tag{20}$$

where $\bar{g}$ denotes the expected rate of growth of output and var denotes the variance of the growth rate. In addition to the conditions imposed in equation (1), we require $\partial\bar{g}/\partial\, var > 0$ and $\partial^2\bar{g}/\partial\, var^2 < 0$ (*cf.* Fig. 4). The associated actual growth rate $\tilde{g}$ is a normally distributed random variable with mean $\bar{g}$ and variance var.

Firms have to choose from a set of investment projects which are not equally risky. From the projects with given growth and employment characteristics the least risky ones are chosen first. Hence at a larger rate of investment the firm has to accept *ceteris paribus* a higher risk on the average project. Following Lintner (1971), a direct dependence between the average riskiness (var) and the rate of investment (σ) is postulated:

$$var = v_0 + v(\sigma) \qquad \partial v/\partial\sigma \geqslant 0 \quad \partial^2 v/\partial\sigma^2 \leqslant 0 \tag{21}$$

A larger investment ratio leads to a greater variability in growth rates. The constant v_0 is a basic risk variable which can be chosen in an optimal way.

In this section we return to the case that shareholders, in their capacity as owners, determine company policy and that managers have no incentives or possibilities to deviate from this policy. The efficiency of stock and bonds markets will guarantee that in a market economy the value of the firm, materialized in stock and bond prices and in interest rates, reflects the preferences of the investor, who is to be identified with our representative consumer. Managers are risk neutral and maximize the value of the firm. But, as the investor is risk averse, the cost of capital for the firm is influenced by the risk-growth mix chosen. Hence, the growth strategy of the firm has to take into account how consumers regard the trade-off between growth, risk and the rate of return. To avoid lengthy derivations for stock prices, etc., we treat the consumers' and firms' decisions as one single decision. This allows us to define an implicit real rate of return that would prevail in an efficient capital market.

The familiar intertemporal utility function is maximized. As the outcomes of the growth process are uncertain, it is the expected value of discounted utility that matters. The objective function can then be stated as:

$$E(U) = E\left[\int_0^\infty \frac{c_i^{1-\rho}}{1-\rho} e^{-\theta t}\,dt\right]$$

$$= \frac{c_i(0)^{1-\rho}}{1-\rho}\int_0^\infty E\{e^{[(1-\rho)\tilde{g}_c-\theta]t}\}\,\mathrm{d}t \qquad \rho > 1$$

where E denotes the expectations operator.

Applying the standard formula for the expected value in the expression for $E(U)$ and substituting $c_i = (1-\sigma)y_i$ yields:

$$E(U) = \left[\frac{[y(0)/l(0)]^{1-\rho}}{1-\rho}\right]\frac{(1-\sigma)^{1-\rho}}{\theta + (\rho-1)(\hat{g}-g_n)} \tag{22}$$

with

$$\hat{g} = \bar{g} - (\rho - 1)\cdot var/2 \tag{23}$$

denoting the *certainty equivalent* of the growth rate of per capita consumption. It should be noticed that in deriving equation (22) account is taken of the aggregation relation $\tilde{g}_c = \tilde{g} - g_n$.

Maximization of equation (22) with respect to σ and v_0 and setting $y(0)/l(0) = 1$ for convenience gives, after some manipulations,

$$(1-\sigma)\cdot \partial\hat{g}/\partial\sigma = [\theta + g_n + \rho(\hat{g} - g_n)] - \hat{g} \tag{24}$$

$$\partial\hat{g}/\partial v_0 = 0 \tag{25}$$

Equation (24) corresponds to equations (7) and (9). The term in square brackets represents the (implicit) rate of return. Under uncertainty the proportionate marginal product of investment corrected for growth costs should be equal to the rate of time preference minus the growth rate, both evaluated in terms of the certainty equivalent of the growth rate. Equation (25) implies an optimal level of "basic" risk that maximizes the certainty equivalent of the prospective growth rate. Differentiation of equation (23) with respect to σ and v_0 respectively, taking equation (21) into account, results in

$$\partial\hat{g}/\partial\sigma = \partial\bar{g}/\partial\sigma + [\partial\bar{g}/\partial\, var - (\rho - 1)/2]\partial v/\partial\sigma \tag{26}$$

$$\partial\hat{g}/\partial v_0 = \partial\bar{g}/\partial\, var - (\rho - 1)/2 \tag{27}$$

Combination of equations (23)–(27) leads to the following first-order conditions for maximization of the expected value of intertemporal utility:

$$(1-\sigma)\partial\bar{g}/\partial\sigma = \theta + (\rho - 1)[\bar{g} - g_n - (\rho - 1)\, var/2] \tag{28}$$

$$\partial\bar{g}/\partial\, var = (\rho - 1)/2 \tag{29}$$

Equation (29) reflects the trade-off between the benefits and costs of a higher variance. In the optimum, the marginal gain in the form of a higher growth rate should be equal to the marginal cost in the form of more risk, which is disliked by shareholders. This condition is illustrated in Fig. 4 where the fundamental growth equation (20) with σ and g_l fixed is tangent to the indifference curve U_2 (derived from equations (22)–(23)) at point A.

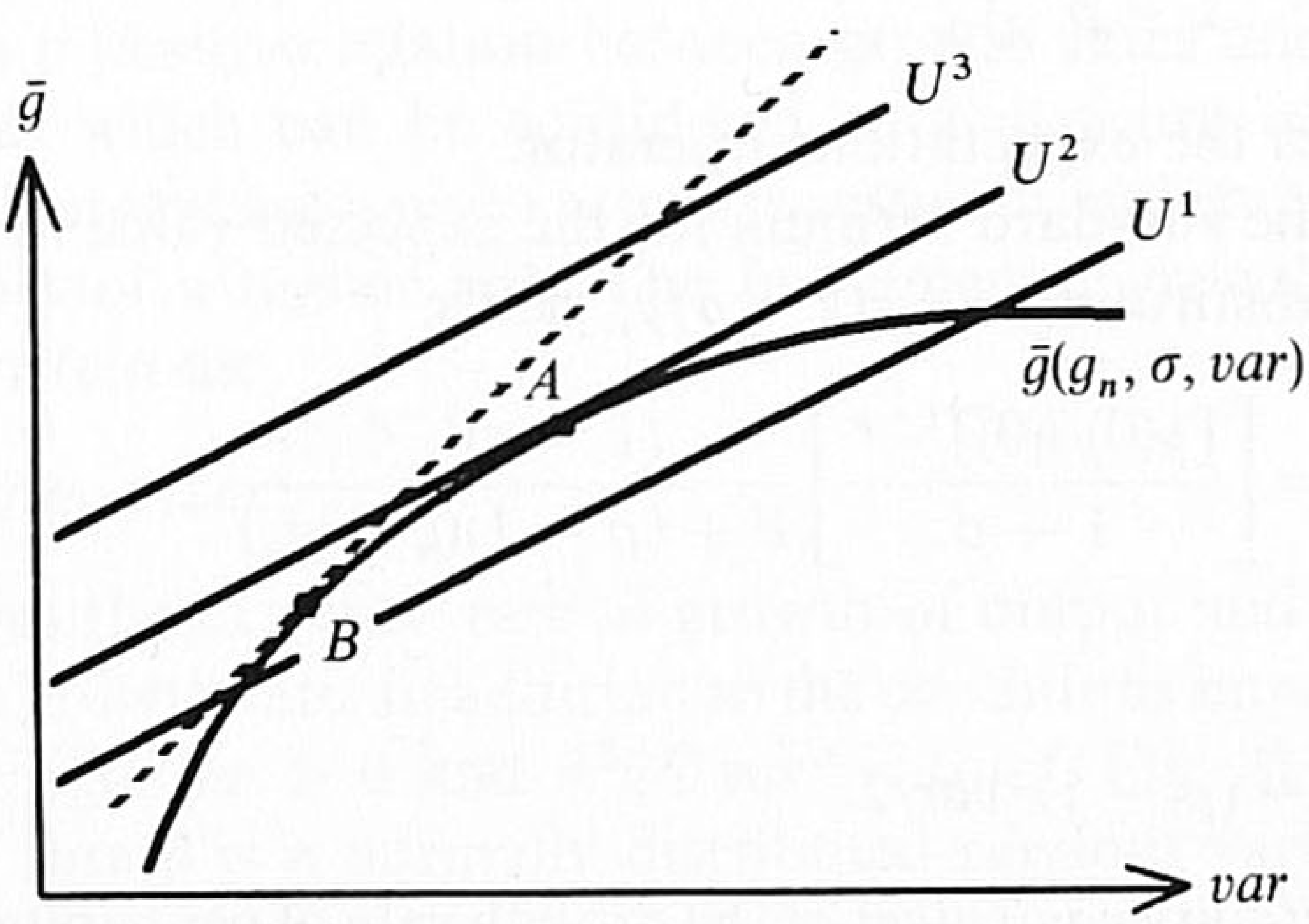


FIG. 4 The Optimal Trade-Off between Growth and Risk

The model can be closed by assuming labour market equilibrium given by equation (10). Equilibrium in the labour market requires competitive wage setting. The growth rate of labour supply is exogenous but employment growth can be derived from the familiar condition:

$$(1 - \sigma)\partial \bar{g}/\partial g_l = \lambda \tag{30}$$

Shareholders value the contribution of employment growth on output growth in terms of the certainty equivalent $\hat{g}$. However, because $\partial \hat{g}/\partial g_l = \partial \bar{g}/\partial g_l$ condition (30) determines the optimal labour-saving content of investment projects. The complete model comprises equations (10), (20), (21), (28), (29) and (30), which solve for $\bar{g}$, g_l, σ, v_0, var, and λ. The real rate of interest is implicit and can be set equal to (see (24)):

$$r = \theta + g_n + \rho[\bar{g} - g_n - (\rho - 1)var/2] \tag{31}$$

Comparison of equation (31) with equation (9) shows that the real rate of interest is lower than under certainty, *ceteris paribus*. As a consequence, the investment ratio and the growth rate will be higher than under certainty. More savings are generated because uncertainty creates an additional precautionary motive (see also Blanchard and Fischer, 1989, Ch. 6). Consumers are risk averse and they opt for extra consumption in the future to compensate for the possibility of bad luck with respect to investment programmes. It should be noticed that the optimal rate of growth will also be higher under uncertainty because shareholders exploit the trade-off between growth and risk in an optimal way. As is shown in equations (25) and (29), the level of risk selected maximizes the certainty equivalent of the growth conditional on any investment ratio. The equilibrium rate of interest may therefore be higher than under certainty. Uncertainty pays off in the form of higher rates of return.

Table 3 illustrates the precautionary savings motive and the growth premium of uncertainty. To assess the former effect separately, the first column of the table gives simulation results assuming $\partial \bar{g}/\partial var$ and v_0 are exogenous. Comparing these results with the case of certainty (Table 1, benchmark), we see that under uncertainty consumers opt for a higher average rate of growth to insure against possible misfortune in the future. The higher average growth rate is reached by choosing a higher savings rate. The positive impact on growth is rather weak when the precautionary savings effect is isolated. What makes a substantial difference is the possibility to opt for higher growth rates at the expense of increased uncertainty (e.g., Black, 1987, Ch. 10). This is illustrated in the second column where $\partial \bar{g}/\partial\, var$ and v_0 are endogenous. To facilitate a comparison between uncertainty with and without direct growth effects, the basic risk level v_0 in the latter case was set at the endogenous level obtained in the former case. Again consumers opt for higher growth when faced with uncertainty. However, because firms confront uncertainty instead of avoiding it, the return of investment is higher. A growth premium is the reward for the acceptance of a higher risk. If the growth premium effect is large relative to the precautionary savings effect, the desired higher growth rate may be realized at a lower savings rate. This actually occurs in the simulation shown in the second column: growth is higher than under certainty but the savings rate is lower.

TABLE 3[a]

	Precautionary Savings Isolated	*Precautionary Savings and Growth Premium*	*Increased Risk Aversion*
g	3·42%	3·97%	3·62%
σ	0·1932	0·1761	0·1388
λ	0·7422	0·7565	0·7859
r	8·88%	10·26%	11·93%
var	0·0009	0·0009	0·0005

Note: [a] See Table 1.

Finally, we can test the sensitivity of the results for the degree of risk aversion in the model with direct growth effects of uncertainty. A less tolerant attitude towards risk leads to a slower rate of growth as shown in the third column of Table 3. The effect on the growth rate is much stronger than in models without uncertainty because shareholders trade-off growth for more certainty. In terms of Fig. 4, increased risk aversion causes the slope of the indifference curves to rise and a point like B is chosen. The variance declines substantially as shown in the table. The (implicit) rate of return rises as households reduce savings, so that diminishing returns to investment bite less.

VII CONCLUSIONS

The analysis presented is based on two main ideas. First, long-run economic growth is endogenous. Our theory therefore fits into the new growth theory which has been developed recently. It deviates from this theory by introducing a fundamental growth equation as substitute for the traditional production function. Second, economic growth is strongly influenced by institutional and strategic factors. To deal with these factors it is necessary to have a flexible theory of economic growth, which is precisely the aim of the approach chosen here.

Learning externalities, managerial discretion and uncertainty of returns to investment are incorporated in a model of economic growth which builds upon the seminal work of Scott (1989). In some instances there is room for strategic behaviour of entrepreneurs in the traditional sense. The outcomes of the decisions of the individual entrepreneur depend on the activities of all others. There is strategic interaction (e.g., Cooper and John, 1988), so that waves of optimism or pessimism may make a large difference to outcomes. The concept of strategies for growth may however be given a broader meaning.

The institutional set-up of the economy is man-made and may hasten or hamper growth. This idea is documented extensively in Detouzos *et al.* (1989) with application to the United States. It is against this background that we summarize our main results in the form of a relatively pessimistic growth scenario which shows how the combination of certain institutional features can impede the potential for growth in a serious manner.

If communication between firms is very difficult, the possibilities for learning-by-watching are not fully exploited. Moreover, firms do not internalize the externalities that remain if there is insufficient trust that others will do the same. The organization of the capital market may not leave much room for managerial discretion and maximization of growth rates. Even when there is some separation of ownership from control, the effects on growth rates are modest as managers compete for workers in a tight labour market. The capital market may be organized in such a way that risk discourages investment. If the precautionary motive for savings, which may lead to higher growth rates under uncertainty, is set aside or if risk aversion is relatively strong, uncertainty adversely affects economic performance.

APPENDIX

Following Scott we assume that the fundamental growth equation (1) is linearly homogeneous in g_l and $q(\sigma, \sigma_s)$ so that we may write $g = q \cdot f(g_l/q)$. The function $f(\cdot)$ can be represented by a single curve shaped as in Fig. 1, but now with g_l/q and g/q on the axes. To allow for uncertainty, we add a term dependent on *var* so that the growth equation is given by:

$$g = q(\sigma, \sigma_s) \cdot f(g_l/q(\sigma, \sigma_s)) + F(var)$$

The following specifications are chosen:

$$q(\sigma, \sigma_s) = \frac{1 - \exp(-\gamma\sigma)}{\gamma_s/2} \cdot \frac{1 - \exp(-\gamma_s\sigma_s)}{1 - \exp(-\gamma\sigma_s)}$$

$$f(g_l/q) = 0{\cdot}1085 + 0{\cdot}955 g_l/q - 0{\cdot}4(g_l/q)^2$$

$$F(var) = \phi \cdot var^{0{\cdot}1}$$

Equation (21) is specified as:

$$var = v_0 + v_1\sqrt{\sigma}$$

The specification of $q(\cdot)$ is chosen in such a way that there is no externality if $\gamma_s = \gamma$ and there is a positive learning externality if $\gamma_s < \gamma$. The specification of $f(\cdot)$ corresponds to empirical results found by Scott (1989) when applying a data set for ten OECD countries. This formulation satisfies the properties imposed on the fundamental growth equation in Section II for empirically relevant values of σ and g_l. The choice of the other parameters is shown in Table A.1 below. The variance in Table 3 is calibrated to 0·0009. This means a standard deviation of 0·03, which corresponds roughly to empirical findings in the Summers and Heston (1991) data set for the 80 richest countries.[7]

[7] We thank Ton van Schaik for providing us with the variances of growth rates.

TABLE A.1
PARAMETER CHOICES

	Table 1	Table 2	Table 3
γ	6, 6, 6, 6	6	6
γ_s	6, 6, 4, 4	6	6
α	—, —, 0, 1	—	—
ρ	2·5	2·5	2·5, 2·5, 3·5
ϕ	0	0	0, 0·0136, 0·0136
v_0	0	0	0·00045, *, *
v_1	0	0	0·001
θ	0·02, 0·04, 0·02, 0·02	0·02	0·02
g_n	0·01	0·01	0·01

Note: * Parameter endogenously determined.

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